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AUTHENTIC TACTICAL TRAINING FOR THE JOINT STRIKE FIGHTER

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14. ABSTRACT

The objective of this initial congressional-add funded effort developed a high fidelity, physiologically-valid multi-role tactical training testbed. The testbed would serve future work to develop methods and instrumentation required to assess physiological impacts and reactions to high fidelity tactical simulation environments incorporating g-loading cues. This is the first and only Phase of the planned three phases of work that was funded. As part of the Phase 1 effort site visits amongst key research and development expertise were exchanged with a team of 711 HPW/RHA Mesa researchers and subject matter experts going to the Environmental Tectonics Corporation (ETC) facilities and with a team of ETC engineers coming to Mesa to detailed discussions on a variety of requirements for improving flight models, visual representations, and cockpit functionality of simulation-base environments incorporating physiological cues for application to high performance, multi-role tactical operations. In addition, there was continued discussion related to examining and defining requirements for integrating physiologically enhanced simulation environments with fixed base, no motion networked high fidelity distributed mission operations training.

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SUMMARY

This is the Final Report on contract FA8650-07-C-6846, F-35A (JSF) TACModule Research Program, submitted in accordance with CLN0001; Data Item 001. The TACModule is a cockpit simulator that can be installed in the Authentic Tactical Fighting Systems-400 (ATFS-400™ "Phoenix".) Built by the Environmental Tectonics Corporation (ETC), the ATFS-400 Phoenix (See Figure 1.) is a high-performance, multi-axes human centrifuge that accurately replicates the dynamic performance of aerospace vehicles. It provides realistic air combat training in sustained G environments. The ATFS-400 Phoenix is a highly versatile tool that can accommodate different cockpit modules to support training and research with specific aircraft.

This the first phase for this area of work and we envision two additional phases of funding and work to be accomplished. The appropriation adds $1.3M to PE 0602202F, Human Effectiveness Applied Research, project 1123, Authentic Tactical Training (See (House Appropriations Committee Report 109-504, page 259; and Defense Appropriations Joint Conference Report 109-676, page 307). The funding ensured that (a) we have an appropriate team of experts available to access ETC facilities and simulator capabilities for detailed examination and requirements specification of the simulation environment baseline; (b) we would be able to define baseline simulation environment functional and physical fidelity requirements for distributed and stand alone authentic tactical training, rehearsal, exercise, test, and evaluation; and (c) that we could use the Phase I effort as a means of fostering longer term collaborations between 711 HPW/RHP and the Naval Aerospace Medical Research Laboratory (NAMRL) for appropriate human protection, biomedical, and physiological performance research expertise.

The objective of this initial congressional funded effort developed a high-fidelity, physiologically-valid multi-role tactical training testbed. The testbed would serve future work to develop methods and instrumentation required to assess physiological impacts and reactions to high fidelity tactical simulation environments incorporating g-loading cues. This is the first and only phase of the planned three phases of work that was funded. As part of Phase 1, site visits by key research and development experts were exchanged with a team of 711 HPW/RHA researchers and subject matter experts going to the ETC facilities and a team of ETC engineers came to Mesa, AZ for detailed discussions on a variety of requirements for improving flight models, visual representations, and cockpit functionality of simulation-base environments incorporating physiological cues for application to high performance, multi-role tactical operations. In addition, there were continued discussions related to examining and defining requirements for integrating physiologically enhanced simulation environments with fixed base, no motion networked high fidelity distributed mission operations training.

PROGRAM DESCRIPTION

Requirements and Needs:

Developing new approaches to link and extend training fidelity requirements definition methods and combat operator subjective and objective assessment methods from fixed based high fidelity simulation environments to more physiologically dynamic environments requires substantial

research, development, and validation effort. As new weapon systems are introduced into increasingly more complex, multi-role environments, the operational community needs to better understand the demands that these environments place on human operators and on their capacity to perform in all aspects of the weapon system performance envelop.

Over the past 10 years, the United States Air Force and United States Navy have made significant investments in fixed-based, high-fidelity networked simulation to augment, to upgrade, and for continuation training of the operational tactical aircrew. In 2006, the requirement to replace some actual live flying time with simulation devices was mandated. Operational tactical pilots will now be spending an increasingly larger portion of their training time in devices that do not provide all the potentially necessary and appropriate environmental and physiological cues that they are likely to experience in actual combat. This potentially means future combat operators may not have the appropriate preparedness for all the environmental issues they will experience in actual combat. This could result in disastrous consequences, not only in training, rehearsal, and exercise, but also in actual combat. What we hope to establish in this initial effort is a foundation of instrumentation and measurement that will permit us to compare training performance data for personnel in fixed high-fidelity simulation environments with the performance of personnel in more physiologically valid representations of the operational environment for a multi-role weapon system. In addition, we will establish initial environment fidelity specifications and parameters for improvements that need to be made to the training environments to improve in-training and training transfer performance.

Science and Technology challenges associated with high-fidelity tactical simulation environments incorporating g-loading cues include aeronautical model matching, compact yet high resolution displays usable in a high-g environments, and unique simulator cockpit designs that minimize weight and size while retaining the required level of immersion. Merging aeronautical models of the flight simulator to match anticipated acceleration characteristic and physical limitations of the overall training device is critical to ensure realistic flight cues are presented to combat operators. In this initial effort we will prototype a high-fidelity aeronautical model that appropriately matches the anticipated flight envelope provided by the Authentic Tactical Flight Simulator. Additionally, we will perform a detailed requirements analysis of simulator cockpit and display design for high-g environments emphasizing integration of advanced training technologies.

Goals and Objectives of the Research and Development:

Phase I accomplished preliminary development and initial validation of baseline simulation functionality, fidelity requirements and metrics, and plans for Phase II and III to extend 711 HPW/RHA research in performance measurement and feedback to a physiologically-valid environment. Phases II and III are presently unfunded but are planned to involve completing remaining phase I tasks and also for developing, validating, and demonstrating progressively higher fidelity non-motion-based and more g-load-based simulation environments as local training environments and as part of a larger Distributed Mission Operations (DMO) integrated environment and capabilities.

Phase I Accomplishments (See Project Completion Summary for Additional Details):

Progress in Phase I on the development of higher fidelity simulation components for the ATS-400 Phoenix was been superb. The concept of a 'hot swappable' medium to high-fidelity cockpit environment on a high-fidelity centrifuge system, is a unique improved quality approach to physiological training and rehearsal activities. Our collaborative research activities were very productive with the development of a multirole tactical training simulation environment, the development of data specifications for a generalizable tactical fast jet flying model (both of these to be evaluated and validated if the next phase if funding is provided); specifications for linking objective tactical mission performance measures with physiological measures of stress, situation awareness, g-performance, and multirole aircraft metrics. This linking represents a unique opportunity for research that cannot be done anywhere else or with other devices because other devices lack the coincident fidelity of the centrifuge itself and the progressing work on the cockpit environments.

Phase I Issues and Challenges:

Because the F-35A aircraft is in production, this project presented numerous challenges. In addition, with the exception of trade-show demonstrators and cockpit configurations, virtually all other aspects of the F 35A cockpit design, functionality, and displays are highly classified. ETC did not have the required personnel with clearances, nor did they have a facility capable of supporting F-35A work at the appropriate levels of classification needed. This made gaining access to drawings, dimensions, specifications and other cockpit environment components extremely difficult. If the Government research team had been able to obtain these materials, we would have been prohibited from sharing them with ETC given the classification issues. As “outsiders” to the F-35A program, and although the Government team worked tirelessly to get releasable information, they were not involved in the F-35A research program and could not help as much as desired. Through its own initiative and creativity, ETC was able to obtain aircraft touch screens and quality aftermarket components to produce a complete cockpit that was accurate for the F-35A aircraft (at the time of the TACModule cockpit production). Additionally, ETC was also able to source software to drive the touch screen display but could not deliver it due to non-available funding.

Obtaining F-35A aircraft performance data and an aero model was even more difficult. Given the classification and access issues discussed earlier, access to any functional, much less flying data for the actual F-35A was a nonstarter. As a fallback, and given ETC’s extensive international collaborations, ETC suggested that it was in possession of several workable flying models that could be tailored to work for the F-35A TAC module. However, none of these models could be modified due to non-availability of funding. To attempt to address this difficulty, the Government research team started developing a scalable flying model, based on the multirole F16, that would permit ETC and other teams to scale or adjust the aero model for appropriate performance parameters and flight characteristics and that work is in its final stages of development and validation today, but we were unable to complete that work in time for its application to the Phase I effort. Consequently, ETC did not receive this aero model and, in turn, was not integrated into the F-35A TACModule.

Progress Review meetings were conducted per the contract schedule. The first meeting was a *de facto* meeting between the ETC team and the 711 HPW/RHA team at I/ITSEC in Orlando,

Florida, in November 2007. ETC provided selected interim reports documenting their progress and their issues in obtaining technical data and cockpit equipment as originally proposed. The second Progress Review meeting was held at ETC Southampton, Pennsylvania, in August 2008. At that time ETC had reached the available contract funding limit. This was discussed at the meeting. Subsequent discussion established that no additional funding was available from 711 HPW/RHA. Dr. Winston Bennett requested that ETC notify the AFRL contracting office of their progress to date and what could be done with the remaining available funding. After consulting with the Government contracting office, the Government Principle Investigator, Dr. Winston Bennett recommended that ETC stop work when remaining available funding was nearly spent. ETC reached the available funding limit in September 2008 and submitted a final invoice in October 2008. No further work was done on the project. Agreement was made that work would resume only if additional funding became available.

CONCLUSIONS

This project had lofty product development goals and a significant research emphasis at the outset. Although continued funding was not forthcoming, the team accomplished a number of advances in both simulation and in the integration of modest fidelity simulation with a high fidelity, centrifuge-based environment. Integrating the multi-role TACModule into the ATFS-400 Phoenix has potential for continued research and development. Both ETC and the 711 HPW/RHA team support continuing the research, should additional funding be available, in the future.

If additional funding can be obtained, completion of remaining Phase I activities, along with Phase II and III activities will continue as appropriate and practical. Examples of these future activities include:

1. Completion of the F-35A TACModule
2. Performance testing for validation of the F-35 TACModule for conformance to USAF required simulator flight characteristics
3. Evaluation of the ATFS device capability to produce and receive DIS data and evaluate network potential for an unclassified DMO demonstration
4. Integration of the Multi Unclassified Threat System (MUTS) into the F-35A TACModule. 711 HPW/RHA would provide the MUTS that ETC would integrate into the cockpit
5. Integration by ETC of the HLA protocol so the F-35A TACModule can be data linked into the 711 HPW/RHA Live Virtual Constructive simulation
6. Collaboration on fidelity surveys and protocols so ETC can gather fidelity ratings from SMEs
7. Identification of metrics - both physiological and mission performance level – for tracking performance with the ATFS and with 711 HPW/RHA's embedded performance measurement system PETS
8. Conduct an unclassified connection trial between the F-35A TACModule and 711 HPW/RHA LVCsimulation.

ETC pursued additional funding through Congressional appropriations in 2009 for the continuance of the F-35A TACModule research without success. No additional work will be done on this project by ETC unless additional funding is obtained.

PROJECT COMPLETION SUMMARY

The project consisted of the following Task:

- Build and validate an F-35A TACModule™ for integration into the ATFS-400 Phoenix, currently located at ETC's main facility in Southampton, PA.

To accomplish this task, ETC identified the following subtasks:

a) Determine requirements and engineering challenges to design and build the F-35A TACModule™
   - This task was completed and verified at the Progress Review meeting, August 2008.

b) Design the F-35A TACModule™
   - Design was completed and verified at the Progress Review meeting, August 2008.

c) Design / write, integrate, and implement aero model software
   - This task presented significant challenges. Performance data for the F-35A aircraft was not available and ETC could obtain these data commercially. ETC proposed solutions and models were assessed to too much additional effort for the funding available. The 711 HPW/RHA research team began working on a scalable aero model that could have been used by ETC had timing worked out appropriately. It did not and the model, while undergoing testing and validation at Mesa, AZ could not be provided to ETC before their funding ran out. Therefore, it was not integrated into the F-35A TACModule™. Prior to implementing an ETC aero model, ETC reached the contract available funding limit and no additional funding was made available by 711 HPW/RHA. Therefore, this subtask was not completed.

d) F-35A TACModule™ Production
   - Production of the TACModule™ was initiated according to the contract schedule. ETC completed the TACModule™ to the following levels.
     - Material Procurement – Complete
     - Mechanical Design – 95% Complete
     - Mechanical Assembly – 95% Complete
     - Electrical Design – 95% Complete
     - Electrical Assembly – 20% Complete
     - Software integration – 60% complete

The remaining production was not completed due to lack of additional funding availability.

e) Validation of the F-35A TACModule™ for conformance to USAF required simulator flight characteristics

   - This subtask was not initiated due to lack of available funding.

Figure 1. Authentic Tactical Fighting System-400 (ATFS-400 Phoenix.)

Figure 2. F-35A TACModule™